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Identifying Individual Bald Eagles With Voiceprints: a feasibility study

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The ability to identify bald eagles (*Haliaeetus leucocephalus*) by voice would eliminate the need to capture, handle, and mark them in order to study certain aspects of their life history. Calls of breeding adults were recorded at 16 eyries in northern California in 1979 and 1980, and sonagrams (voiceprints) were prepared of all recordings. Samples of "chatter" calls were compared for individual differences within and between years. Unknown samples were correctly matched to birds between years significantly more often than predicted by random pairing. Although inconclusive, the results support the hypothesis that "chatter" calls of individual bald eagles differ markedly. More detailed sonagraphic analyses and permanent marking of a small number of eagles are needed to further study this promising technique.

Retrieval Terms: bald eagles, individual recognition, voice, California, management

The ability to identify individual animals over extended periods of time is essential in the collection of information needed for effective wildlife management. For example, quantitative assessment of dispersal of animals between breeding seasons depends on our ability to recognize individuals. Knowledge of identity facilitates construction of life tables, which are needed to characterize population dynamics. Age at first reproduction—a key element in assessing population growth potential—may be learned only through recognition of individuals. And assessment of territory or home range size is also facilitated if individuals can be recognized.

Various methods have been used to mark animals for individual recognition, but they all have limitations. They require capture and handling of animals and usually leave them with a marker that makes them conspicuous to the researcher, as well as to conspecifics and other species. Markers, therefore, may interfere with normal behavioral interactions and may increase vulnerability to predators. Such treatment could be hazardous to certain rare and endangered species.

Ornithologists have known for a long time that some birds can distinguish among individuals on the basis of differences in vocal characters. For example, Craig reported in 1908 that one function of a rock dove's (*Columba livia*) "song" is to proclaim its identity,[1] and early field studies showed that gulls recognize one another by vocal cues.[2] If we could analyze bird songs or calls in sufficient detail, we, too, might be able to distinguish individuals on the basis of voice.

Quantitative analysis of animal sounds became a reality nearly three decades ago, with development and production of the sound spectrograph by Kay Electric Company.[3] Since that time, many studies have shown that individual birds of various species differ significantly in their vocal characters.[4 5] These studies suggest the possibility that vocal distinctiveness among songs of individuals might be used to assist in censusing, mapping territories, and studying mortality rates and local movements.[5 6] A major advantage would be elimination of the need to capture, handle, and mark the birds.

This note reports a study of calls of bald eagles (*Haliaeetus leucocephalus*) at eyries in northern California in 1979 and 1980. The study sought to determine whether individual distinctiveness among calls can be used to investigate aspects of the eagle's life history, including seasonal or yearly dispersal between nest sites or territories, long-term survivorship, and perhaps the source of birds aggregating in winter roosts. Although preliminary results are inconclusive, they suggest that the technique of using sound spectrographic analysis of calls to identify individual birds shows promise.

STUDY AREAS AND METHODS

From April 23 to June 9, 1979, we recorded the calls of 16 bald eagles at 11 nest sites in northern California—10 sites in Shasta County and 1 site in Trinity County. From April 14 to June 26, 1980, eight of those sites were revisited and recordings were made of 13 eagles presumed to have been recorded in 1979. Calls of 13 additional eagles were recorded in 1980, including several at five additional sites in Shasta County.

We started recording calls 7 to 14 days after most eggs had hatched, to minimize the chance that our presence might cause nest desertion. Access to some nest areas was possible only by boat, but the final approach to each nest site was made on foot.

Calls were recorded on a Uher 4000 Report IC, 12.7-cm, reel-to-reel tape recorder at a tape speed of 19 cm/s, with an ultradirectional, condenser microphone, Sennheiser model MKG-815. We spent 2 to 4 days at each nest site each year to obtain at least 20 minutes of footage for each site. Most calls recorded were induced by the investigator approaching the nest, although some calls apparently were given in response to other stimuli, such as turkey vultures (*Cathartes aura*) flying nearby. Whenever possible at a nest site, we recorded each bird calling individually and both birds calling simultaneously. This approach facilitated differentiating calls of the members of each pair. We emphasized recording early in the morning and late in the evening, when the wind generally was calmer and human-related environmental noise was reduced.

Sonagrams were prepared on a Kay Electric Company sound spectrograph, model 6061B, at wide band-pass filter and Fl-1 settings. All sonagrams were identified with one member of the pair and visually compared for individual differences within and between years. But since the eagles were not marked, we could not be certain that, at a given nest, eagles recorded in 1980 were the same as those recorded in 1979. Assuming no replacements of individuals between years, we tested the accuracy with which observers could match sonagrams of the "same" individuals from one year to the next.

We selected samples of sonagrams from 16 eagles recorded in 1979 for comparison with eagles recorded in 1980. Each sample contained one or more sonagrams from one eagle. Sonagrams of 10 different calls were selected at random from calls of each of 14 eagles; sonagrams of 7 calls were selected from one eagle; and sonagrams of 4 calls were selected from one eagle. Each sample was identified by letter code only. Similarly, samples of sonagrams from 10 eagles recorded in 1980, which presumably were also recorded in 1979, were chosen to make 30 test samples—three samples for each eagle. The first sample contained one sonagram, the second contained three, and the third contained five, to obtain information on the minimum number of sonagrams needed to accurately match samples between years. Individuals and specific sonagrams were chosen at random. Ten volunteers, inexperienced in studying sonagrams, were asked to match the 1980 samples to the 1979 samples. To prepare them, we spent about an hour explaining the basics of sound analysis. This included a demonstration of sonagram preparation, some of the sources of instrument bias, recording conditions that affect the quality of sonagrams, and what to look for in matching the sonagrams, such as frequency characteristics, note shapes, and timing of note delivery.

RESULTS

If we approached the nest on foot within sight of the eagles at their nest, they generally flushed when we were at a distance of 100 to 300 m, after which they circled above and called loudly. They occasionally flushed from the nest when we were as far away as 450 m. Certain individuals, however, were more tolerant of our approach. One pair, with its nest about 25 m from the shoreline of a reservoir in a popular recreation area, regularly stayed on the nest until we were within 50 m. At a nest within 35 m of regular human activity, one member of the pair never left the nest as the investigator approached the base of the nest tree. Its mate, however, flushed at an approach distance of about 100 m, circling above and calling as we came nearer.

We found that the eagles could be recorded from as far away as 300 m; however, the poor quality of such recordings usually precluded preparation of clear sonagrams. Usually we tried to obtain recordings from within 100 m, and we usually could elicit calls from the eagles by approaching the nest that closely. Typically, one member of the pair was more vocal than the other, perhaps indicating dominance. In some of these cases we obtained no usable footage from the less vocal eagle.

We identified three major call types among the sonagrams. The "wail" (*fig. 1*) was seldom given in response to our approach, suggesting that it is more common in other contexts unknown to us. The "peal" (*fig. 2*) was apparently used in response to our approach. On two occasions it was given when a turkey vulture passed near the eagles' nest. The "chatter" (*figs. 3, 4, and 5*), used only in apparent response to our approach, was by far the most common call type recorded, and it was also the most variable, both within and between individuals. For these reasons, we selected the chatter for analysis.

Twenty-two of the 30 samples from 1980 were matched with the "correct" 1979 bird significantly more often than predicted by random pairing, that is, by

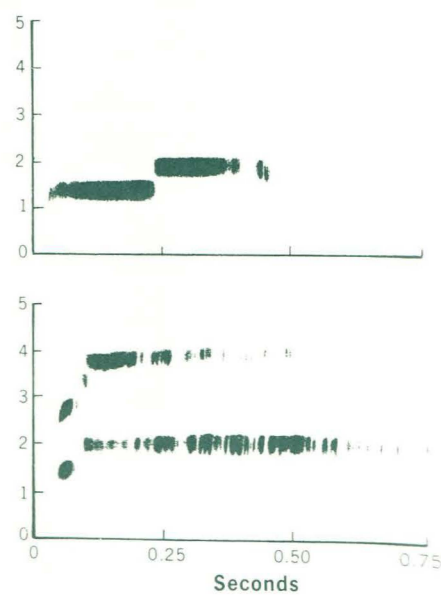

Figure 1—Sonagrams of "wail" calls of two bald eagles.

for 4 volunteers was only 0.002 (*table 1*). We defined a correct match on the basis of our determination of pair members at the same nest site in 1980 as in 1979. Since the eagles were not banded, we cannot be certain that individuals at all nest sites were the same both years. In most instances, however, on the basis of sonagram characters, it was reasonable to assume that at most nest sites the same eagles were recorded in both years.

Collectively, the volunteers made 51 correct matches of 100 possible of the 1980 samples with five sonagrams each, 54 of those with three sonagrams each, and 48 of those with one each. Thus we found no significant increase in the number of correct matches with more sonagrams of an individual eagle's voice to compare—at least up to five sonagrams.

DISCUSSION

Results of the matching tests were undoubtedly biased against higher scores because we did not let the volunteers know where recordings were made in 1980. In an actual comparison, investigators would know where all recordings were made, so they should have a simpler task of matching samples between years. They would only need to decide whether a sample is of either member of the pair recorded at the nest site the previous year. If a sample was from neither member of the pair, then the investigator would have to compare it with samples from other nest sites. Furthermore, because we assumed there were no replacements at any of the nests between 1979 and 1980, some of the consistent "errors" in matching samples may actually have resulted because the bird recorded in 1980 was a replacement for one of the birds recorded in 1979.

The ability of inexperienced volunteers to match correctly many samples verifies that certain features of chatter calls vary markedly between individual bald eagles. However, these results are inadequate to suggest this method for regular field use. The basic sonagram, presenting a time-frequency display, does not provide enough information to assure adequate identification of individual eagles by visual inspection alone.

Our results suggest that refinement of the analysis of eagles' voices is likely to improve significantly our ability to distinguish individuals. For example, parameters of the time and frequency characteristics of individual call notes can be carefully measured. It is also possible to prepare sonagram displays of the amplitude of frequency intervals in the call notes. Statistical analyses of these data can then be used to more objectively distinguish individuals. However, this analysis would add significantly to the time and cost required to identify individual birds. One of our objectives is to find a cost-effective method for reliably identifying individuals by voice that could be applied on a scale large enough to be worthwhile as a management tool. A computerized approach to obtain more refined measurements of note characteristics, and to subject them to statistical analysis, has been developed by Mark Hughes, of California Polytechnic State University, San Luis Obispo.[7] We are currently exploring the applicability of his procedure to eagle calls.

Final documentation of our ability to identify individual eagles with voiceprints will require the capture and marking of some birds to determine the extent to which call characteristics change from year to year in known individuals. And we must explore the method's feasibility in differentiating among a much larger number of eagles.

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NOTES

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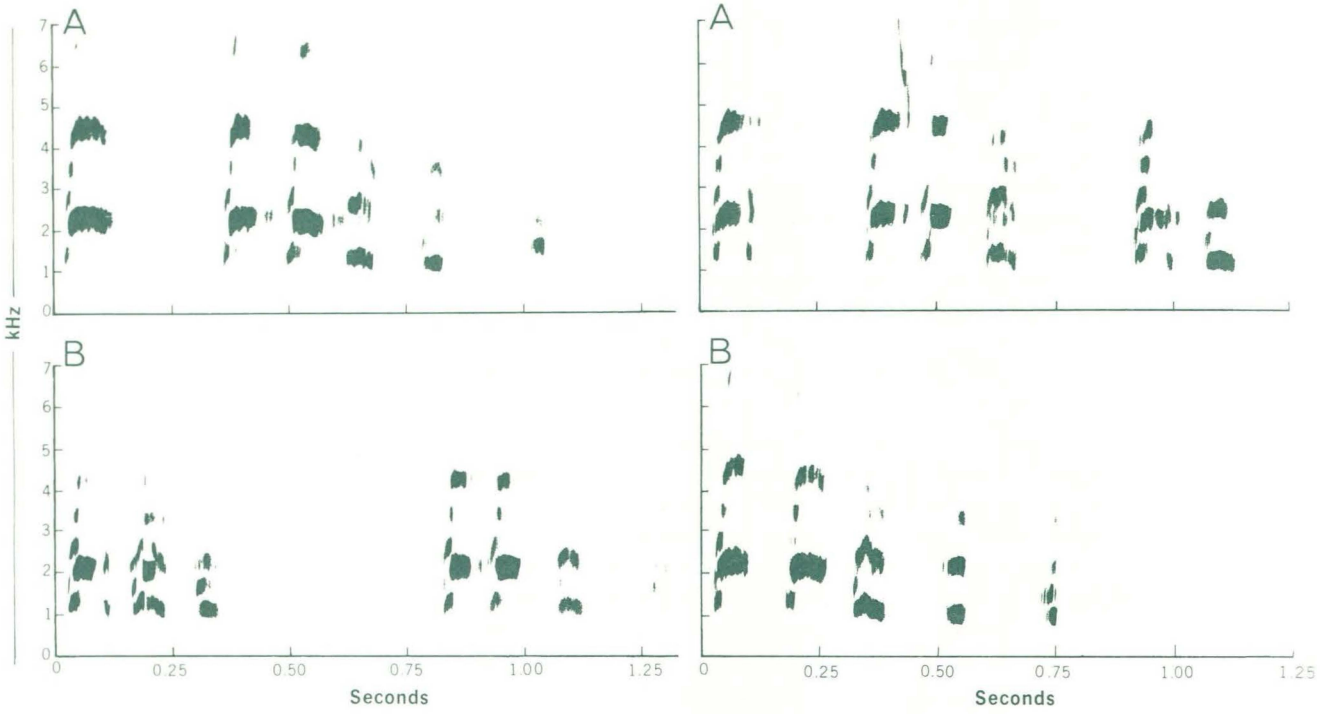

Figure 4—Sonagrams of four different chatter calls of one bald eagle in the same year. (*A*) May 19, 1980, recordings; (*B*) June 24, 1980, recordings.

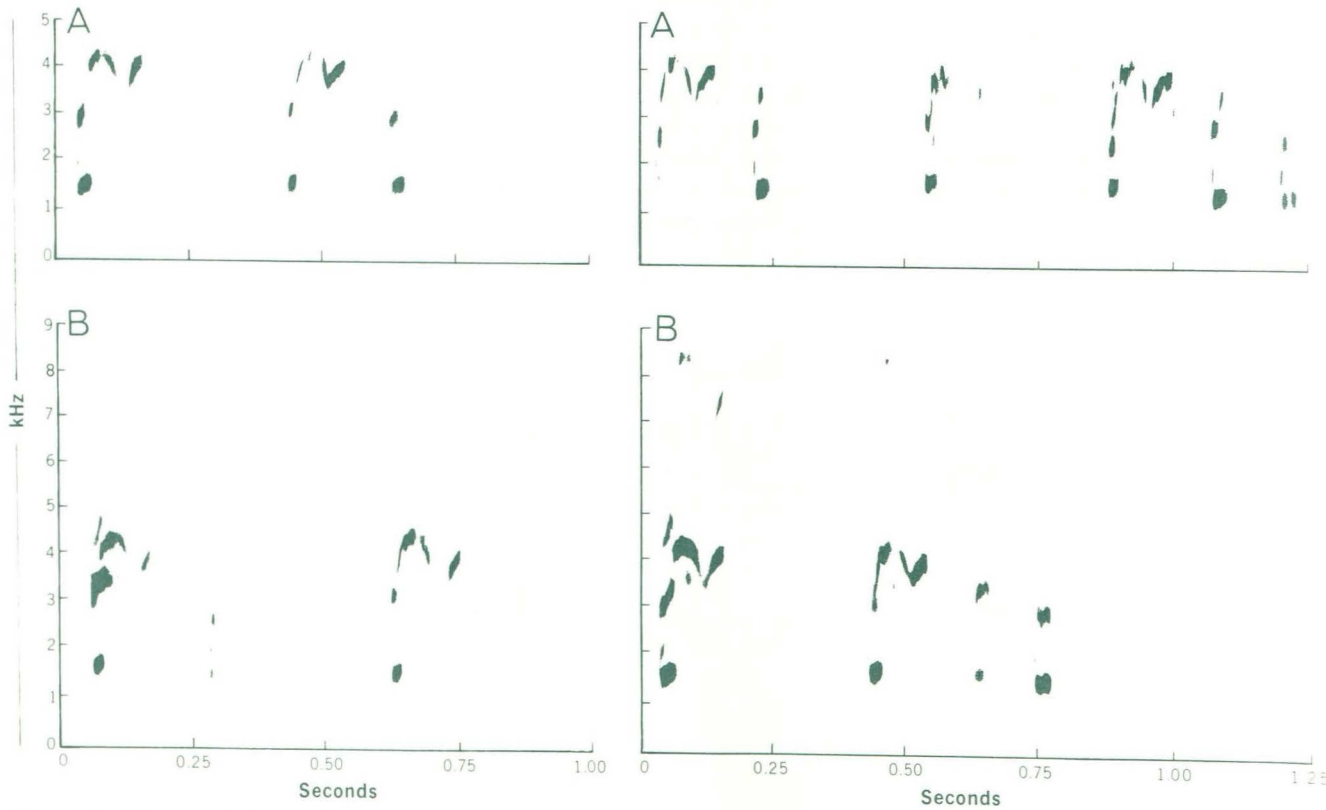

Figure 5—Sonagrams of four different chatter calls, presumably of the same bird in two consecutive years. (*A*) May 19, 1979, recordings; (*B*) June 14, 1980, recordings.

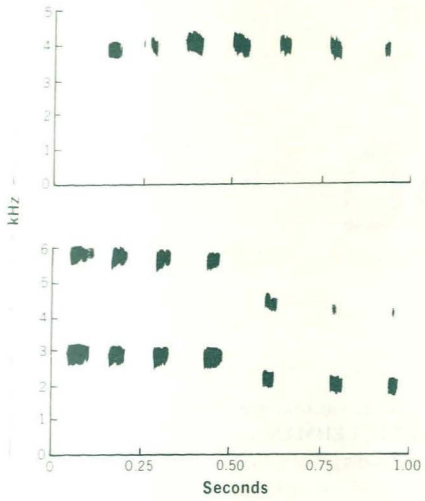

Figure 2—Sonagrams of "peal" calls of two bald eagles.

three or more volunteers (*table 1*). Three samples were correctly matched by 9 of 10 volunteers, and one sample was correctly matched by all 10. Some samples were seldom or never matched correctly. A volunteer randomly matching a 1980 sample to one in the 1979 series had a probability of 0.0625 of making the correct match. The probability that 3 volunteers out of 10 would make the correct match randomly was only 0.02, and that

Table 1—*Correct matches of samples of 1980 sonagrams of bald eagle chatter calls with 1979 samples, by 10 inexperienced volunteers* [1]

Number of possible correct matches (P)[2]		Number of samples	Total correct
0	(0.53)	2	0
1	(0.35)	3	3
2	(0.11)	3	6
3	(< 0.02)	2	6
4	(< 0.002)	1	4
5	(< 0.001)	1	5
6	(< 0.001)	8	48
7	(< 0.001)	4	28
8	(< 0.001)	2	16
9	(< 0.001)	3	27
10	(< 0.001)	1	10
	Totals	30	153

[1]Samples from 1979 had ten (14 samples), seven (1 sample), or four (1 sample) sonagrams; samples from 1980 had one (10 samples), three (10 samples), or five (10 samples) sonagrams.

[2]Probability of 0 to 10 volunteers making a correct match is in parentheses.

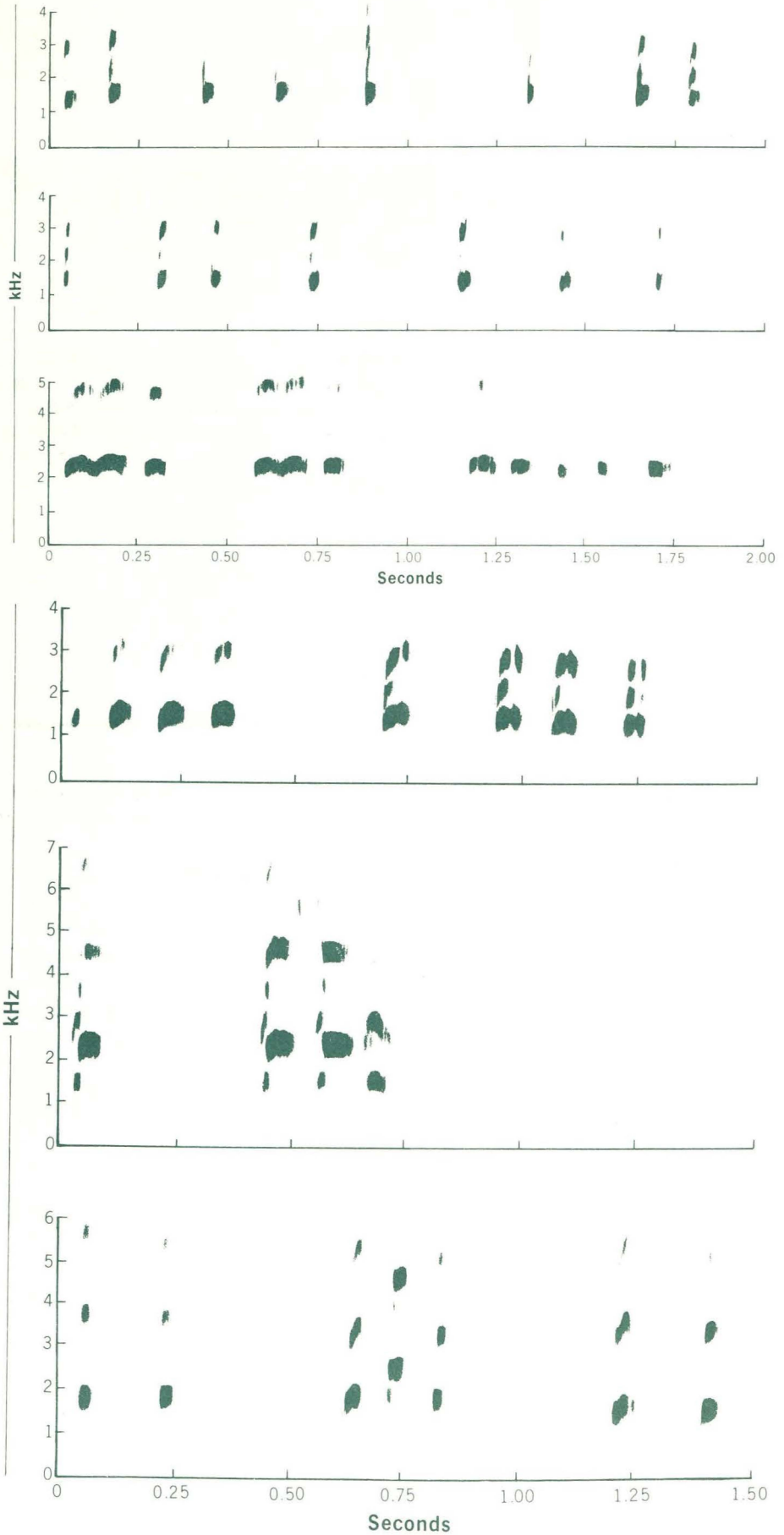

Figure 3—Sonagrams of "chatter" calls of six bald eagles.

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